Answer on Question #66742-Physics-Molecular Physics-Thermodynamics

The mean speed of oxygen molecules is 450 ms-1. If the radius of an oxygen molecule is 1.8 Å, calculate mean time between two successive collisions and mean free path. Take .m103325

Solution

The mean free path is

$$l = \frac{kT}{\sqrt{2}\pi d^2 P}$$

$$v_{av} = \sqrt{\frac{8RT}{\pi M}} \rightarrow T = \frac{v_{av}^2 \pi M}{8R}$$

$$l = \frac{k}{\sqrt{2}\pi d^2 P} \frac{v_{av}^2 \pi M}{8R} = \frac{1}{\sqrt{2}4r^2 P} \frac{v_{av}^2 M}{8N_a}$$

$$l = \frac{v_{av}^2 M}{32\sqrt{2}r^2 P N_a} = \frac{(450)^2(0.032)}{32\sqrt{2}(1.8 \cdot 10^{-10})^2(103325)(6.022 \cdot 10^{23})} = 7.1 \cdot 10^{-8}m = 71 \; nm.$$

The time between two successive collisions is

$$t = \frac{l}{v_{rms}}$$

$$v_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3\pi}{8}}v_{av}$$

$$t = \sqrt{\frac{8}{3\pi}}\frac{l}{v_{av}} = \sqrt{\frac{8}{3\pi}}\frac{(7.1 \cdot 10^{-8})}{(450)} = 4.6 \cdot 10^{-10} \; s.$$

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